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Remote Water Quality Testing Via IoT Using Hydrogen Sulphide

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ABSTRACT:

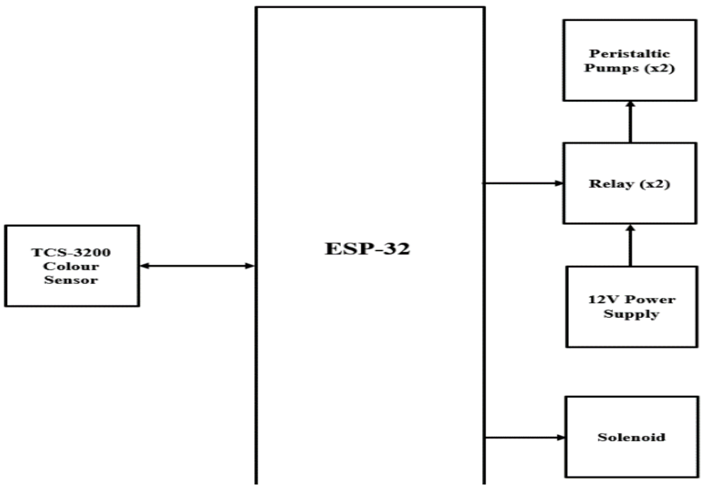
This paper focuses on developing a prototype of an automated system that tests potability of water using Hydrogen Sulphide (H2S). This paper presents an IoT-based water testing system that is an improvement of the age-old paper-strip based water testing method which also uses Hydrogen Sulphide as its key chemical. The proposed system utilizes a color sensor to monitor colour of the testing solution, peristaltic pumps connected to an ESP32 development board which is connected to a Wi-Fi network for uploading data to the Blynk Cloud platform. This paper discusses the working principle, sensor deployment, and the practical benefits that could be observed in practice, providing an overview of the impact of IoT and automation on public health.

Keywords: Internet of Things (IoT), Hydrogen Sulphide, ESP32, Microcontroller, Real-time results, Blynk.

Introduction:

Access to clean and potable water is a critical aspect of public health and environmental sustainability. Ensuring the quality of water resources makes it necessary for us to develop efficient and reliable testing methods. The project aims to develop a novel system that automates the process of determining the potability of water samples by introducing hydrogen sulphide and monitoring subsequent colour changes over a 24-hour period. The significance of this project lies in its potential to revolutionize the field of water testing that is accessible and economical to the public while also offering a more streamlined and technologically advanced solution. Water quality assessment traditionally relies on labor-intensive and time-consuming methods, often subject to the risk of human error. Our project seeks to address these limitations by leveraging the power of automation and Internet of Things (IoT) technology. By integrating smart sensors, controlled release mechanisms, and real-time connectivity, we aim to create a sophisticated system capable of providing accurate and timely results. The proposed methodology involves adding hydrogen sulfide to the water sample, with the ensuing colour change serving as a clear indicator of its potability. A blackened appearance signifies contamination, prompting a swift response, while an unchanged colour confirms the water's safety for consumption.

Methodology:



BLOCK DIAGRAM

Here, it can be observed that we have used an ESP32 module as the central component. The heart of the system, the ESP32 module, serves as the central processing unit. It integrates data acquisition, and communication with peripheral devices. Of the two peristaltic pumps, one is present at the point where the system takes water as an input. The pump which has a maximum flow rate of about 40ml/min, is present at the water intake point. There is another pump connected to a storage tank inside the system that holds the Hydrogen Sulphide solution. Both these pumps dump their intake liquids into a testing container that holds the solution for 24 hours. The testing container has a TCS3200 colour sensor placed parallel to it which detects the colour of the test solution every 24 hours after a new testing cycle begins. The testing container has a solenoid valve attached to its bottom which is opened once the testing is complete to flush out the tested solution. All is automated and the whole cycle repeats in a period of 24 hours routinely. The ESP32 module being connected to Wi-Fi, sends the water test result data to a remote monitoring platform (Blynk) for instant access ensuring convenient monitoring of the water supply quality to ensure and detect any instance where the water sample might not be from a potable source.

Working Principle:

A microcontroller-based development board uses a nominal power supply of 5 volts and controls all the sensors and relays used in this system using the onboard GPIO pins. It can also be connected to a Wi-Fi network to push water quality details to a cloud platform.

Function: Triggers the relays and reads colour sensor data based on time elapsed in every 24-hour cycle.

1. Colour sensor: -

Working Principle: It uses photodiodes (red, green, blue, and clear) which convert light intensity into a frequency output proportional to light intensity of filtered colour.

Function: This sensor monitors the colour of the testing solution in the system to detect if the water is transparent or if it has turned black in colour.

2. Peristaltic Liquid Pump: -

Working Principle: This pump operates by using a flexible tube and a set of rollers attached to a rotor that compresses the tube, pushing the fluid forward through it. This pump is well-suited for handling sterile or corrosive liquids.

Function: Used to pump 20ml of water and 5ml of Hydrogen Sulphide into the testing container.

3. Relay modules: -

Working Principle: It operates as an electrically operated switch that uses an electromagnet to mechanically operate a switch. When an electric current passes through the coil of the relay, it generates a magnetic field that activates an internal switch, allowing a different circuit to be opened or closed.

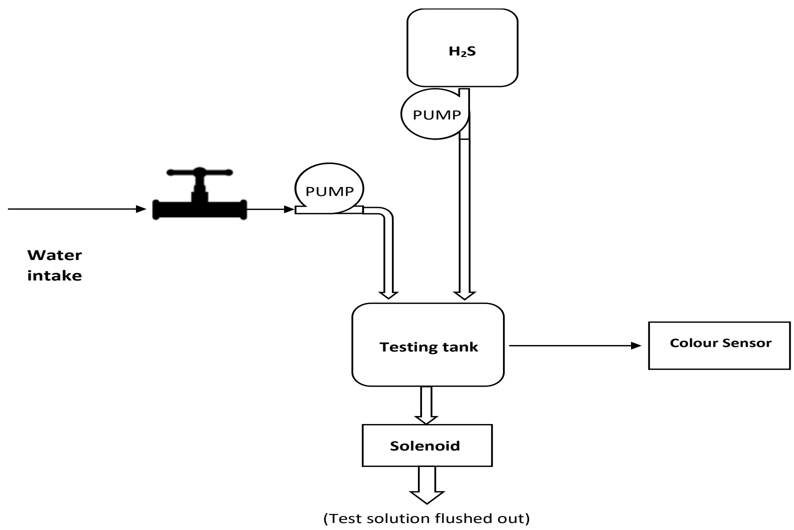
Function: Used in this system to control operation of the peristaltic pumps using logical control signals from the GPIO pins of the microcontroller development board.

4. Blynk IoT: -

Working Principle: Blynk primarily connects IoT devices to the Blynk cloud platform.

Function: It is a platform for connecting IoT devices, using which we can remotely monitor, control, and observe data from sensors by using the Blynk App.

Proposed Prototype



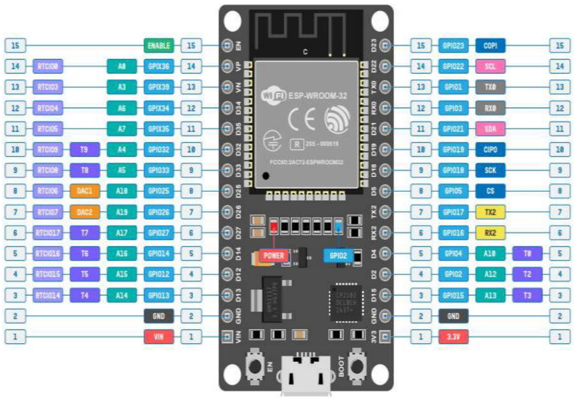
1. **Analyze Requirements**: Identify components that fulfill minimum requirements while consuming minimal power and be cost effective.
2. **Sensor Selection:** Choose appropriate colour sensors to detect accurate changes in testing solution.
3. **Hardware Setup:** Interface the selected sensor, pump motors with relays and to the microcontroller-based ESP-32 development board. Arrange and maintain proper power supply and connectivity for the sensors and the microcontroller.
4. **Network Setup:** Use Wi-Fi for connecting the microcontroller to the internet.
5. **Cloud Integration**: Integrate the hardware system to Blynk Cloud platform and create virtual pins to monitor the data on a mobile app.
6. **Testing the system:** Ensure desirable working of the final system by multiple tests in a controlled environment.
7. **Deployment:** Deploy the water testing system at main water supply/distribution stations. Provide training and make the operators of the system familiar with its operations and its maintenance.

Hardware and Software Requirement

A. Hardware Description

1. ESP-32 Development Board

The ESP32 is a powerful and versatile microcontroller with integrated Wi-Fi capabilities with a total of 30 pins. It operates by using a dual-core or single-core Tensilica Xtensa LX6 microprocessor, making it capable of handling complex tasks and real-time operations. The ESP32 includes a variety of peripherals such as GPIO, ADC, DAC, UART, SPI, and I2C, allowing it to interface with numerous sensors and devices. Its built-in Wi-Fi module enables seamless connectivity for IoT applications. The microcontroller is programmable using popular environments like Arduino IDE, MicroPython, and Espressif's own ESP-IDF, making it accessible for a wide range of applications from simple DIY projects to advanced industrial automation.

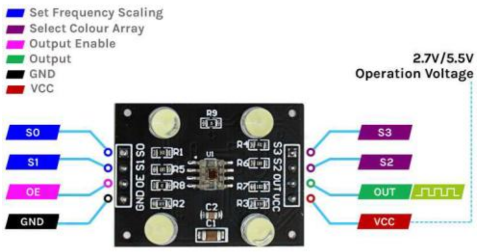


Technical Specifications:

- Microcontroller: Tensilica 32-bit CPU Xtensa LX6
- Input Voltage: 3.3~5V.
- GPIO Pins: 25.
- Analog Pins (ADC): 15.
- Flash Memory: 4MB.
- SRAM: 512KB.
- Clock Speed: 80~240 MHz.

2. TCS-3200 Colour Sensor

The TCS3200 is a colour sensor that can be used to detect and measure the intensity of different colours. It is widely used in applications such as colour recognition, sorting, and other projects where colour sensing is required. The TCS3200 Colour Sensor module has 8 pins. All the pins of this sensor module are digital, except VCC and Ground. The Pinout of a TCS3200 Colour Sensor is shown below.



3. Peristaltic Pump

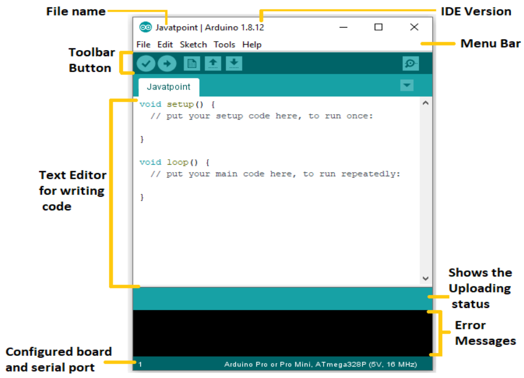
When pumping liquids and no direct contact with the liquid is required, this pump offers a simple solution. Unlike most pumps, peristaltic pumps squish a silicone tube to produce the pump-action instead of sucking it in directly, this means there is no contact with the liquid. This pump requires a 12 V DC supply and can produce a flow rate up to 37ml per minute.

Technical Specifications:

- Operating Voltage: 12V.
- Operating Current: 0.25mA.
- Flow rate: 37ml/min.
- Noise level: <40dB.

B. SOFTWARE DESCRIPTION

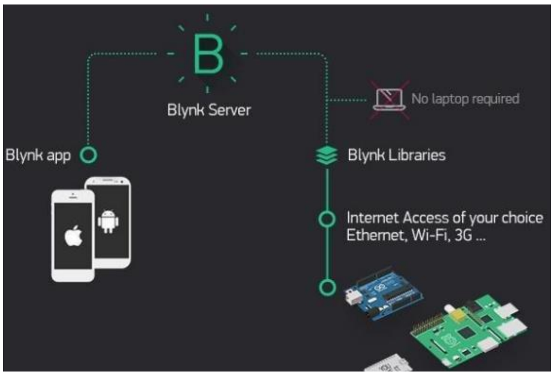
1. Arduino IDE



The Arduino IDE (Integrated Development Environment) is a user-friendly platform designed for writing, compiling, and uploading code to various microcontrollers, including the ESP32. To use the Arduino IDE with the ESP32, the ESP32 board support package is needed. This enables the selection of ESP32-specific settings and libraries within the IDE. The environment provides a simplified coding experience with a vast collection of libraries and examples, making it easy to implement complex functionalities like Wi-Fi, Bluetooth, and sensor integration. Once the code is written in the IDE, it can be compiled and uploaded to the ESP32 via a USB connection, allowing users to quickly develop and deploy IoT projects and other embedded systems applications.

2. Blynk IoT

Blynk is a user-friendly Internet of Things (IoT) platform that allows users to build and control IoT projects through a mobile app and web dashboard. It supports a wide range of hardware, including Arduino, Raspberry Pi, and ESP32, enabling seamless integration with various devices and sensors. Blynk provides a drag-and-drop interface to create custom dashboards for monitoring and controlling connected devices in real-time. Additionally, it features cloud connectivity, automation, and notifications, making it ideal for both beginners and advanced users to develop IoT applications such as home automation, remote monitoring, and data logging with minimal coding effort.



Conclusion

In conclusion, the development of an Automated IoT-Based Water Potability Testing System using Hydrogen Sulphide has significant implications for water quality management. This system aims to address challenges in traditional water testing methods by incorporating automation, IoT technology, and a user-friendly approach. By simplifying the testing process, it expects to improve accessibility, affordability, and reliability in water quality assessments. Real-time monitoring enhances emergency response and empowers communities to safeguard their water sources. The project aims to contribute to public health, economic opportunities, and technological advancements, ultimately creating a healthier, more sustainable future with clean and safe drinking water for all.

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